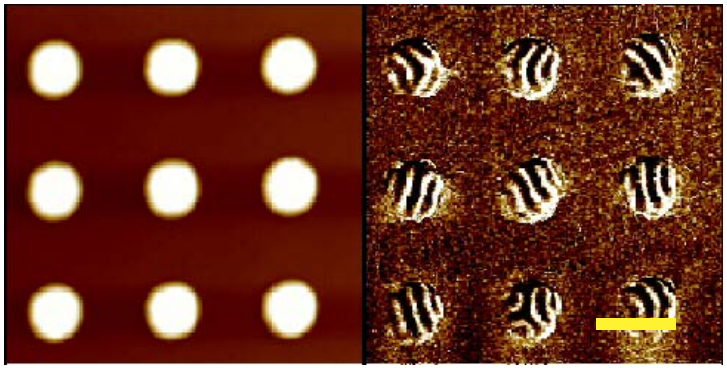
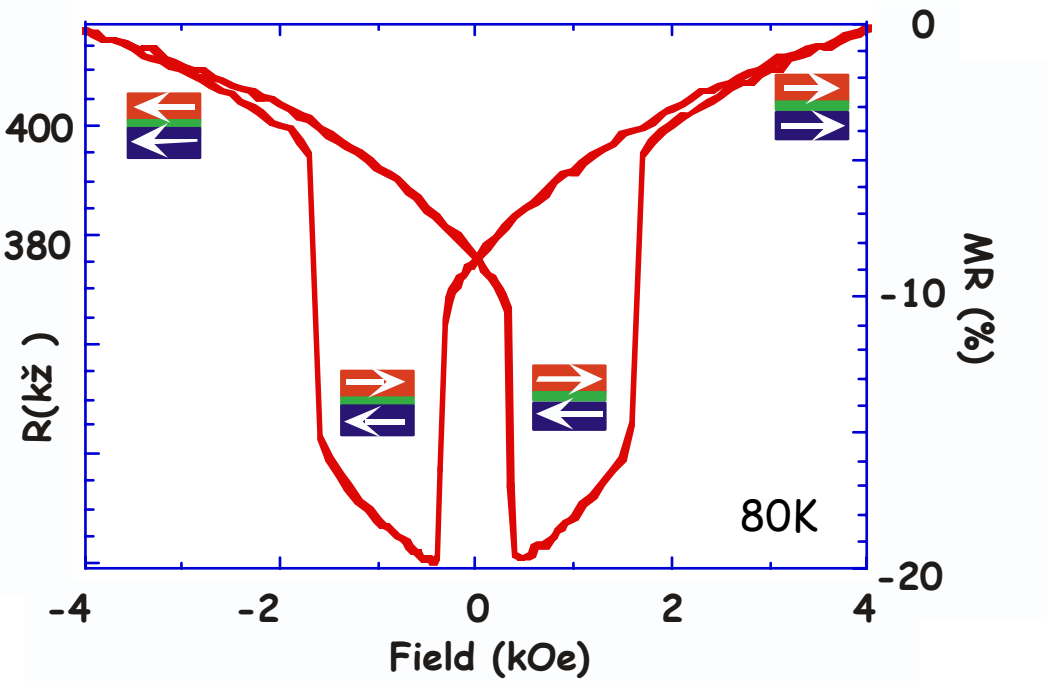
Half Metallicity and Spin Transport

Half-metallicity of doped perovskite manganites and magnetite make them ideal candidates for magnetic tunnel junctions in next generation memory.



Topographic (l) and magnetic (r) images of submicron manganite islands.



Junction magnetoresistance (MR) of a manganite/magnetite-based magnetic junction showing highest MR to date.

Yuri Suzuki
Materials Science and Engineering

CORNELL

Structure-Property Relationships in Colossal Magnetoresistance Thin Films Materials Through Nanofabrication
(DMR 0102621- Suzuki, Cornell Univ.)

Doped perovskite manganites, magnetite (Fe_3O_4) and chromium dioxide (CrO_2) have been identified as possible half metallic ferromagnets with complete spin polarization at the Fermi level. Materials with complete spin polarization are ideal candidates for electrodes of a magnetic tunnel junction since they maximize the junction magnetoresistance. While tunnel junctions based on doped perovskite manganites or so-called colossal magnetoresistance (CMR) materials, such as $La_{0.7}Sr_{0.3}MnO_3$ (LSMO), have been the most successful epitaxial oxide tunnel junctions, junction magnetoresistance (JMR) decrease rapidly with increasing temperature and vanish by room temperature. Epitaxial Fe_3O_4 junctions have shown at best 2% JMR at low temperatures.

In order to understand the disappearance of the JMR, we have been studying (i) the local domain structure and its reversal in submicron CMR islands and (ii) spin transport in epitaxial oxide junctions with a CMR electrode and a magnetite electrode. Magnetic force microscopy reveals, for the first time, the nature of local magnetic structure in submicron islands of CMR thin films (Wu et al. Phys. Rev. B **64** 220404 (2001). The evolution of domains in a magnetic field reveals the importance of shape anisotropy as well as magnetostriction in determining the micromagnetics in such small CMR structures. We have also studied micron size junctions with one CMR and one magnetite electrode. The observation of JMR to room temperature in these junctions suggests that the spin polarization of the CMR material persists up until room temperature, contrary to some have speculated. Transport through these junctions is not the expected direct tunneling but can be understood in terms of hopping transport through localized states that preserves electron spin information. The surprising result that electron spin information is preserved in inelastic hopping processes is of fundamental and technological interest.

The figure on the left shows a topographic (left) and magnetic (right) image of CMR islands made of epitaxial $La_{0.7}Sr_{0.3}MnO_3$ on a $LaAlO_3$ substrate. These image are some of the first images of magnetic structure in submicron CMR structures. The figure on the right shows a plot of junction magnetoresistance versus field at 80K of an epitaxial Fe_3O_4/insulator/ $La_{0.7}Sr_{0.3}MnO_3$ junction. JMR as high as -20% in 4kOe and -33% in 7T have been achieved. The inverse MR is some of the first evidence that the conduction electrons in Fe_3O_4 come from the minority spin band. When the layers have magnetic moments that are antiparallel to one another, the junction exhibits high resistance whereas when the layers are parallel, the junction exhibits low resistance.